# Decadal Variability of Beach-Dune Geomorphic Resilience and Cross-shore Aeolian Fetch in NE Florida

## Applications of the USACE Coastal Engineering Resiliency Toolbox

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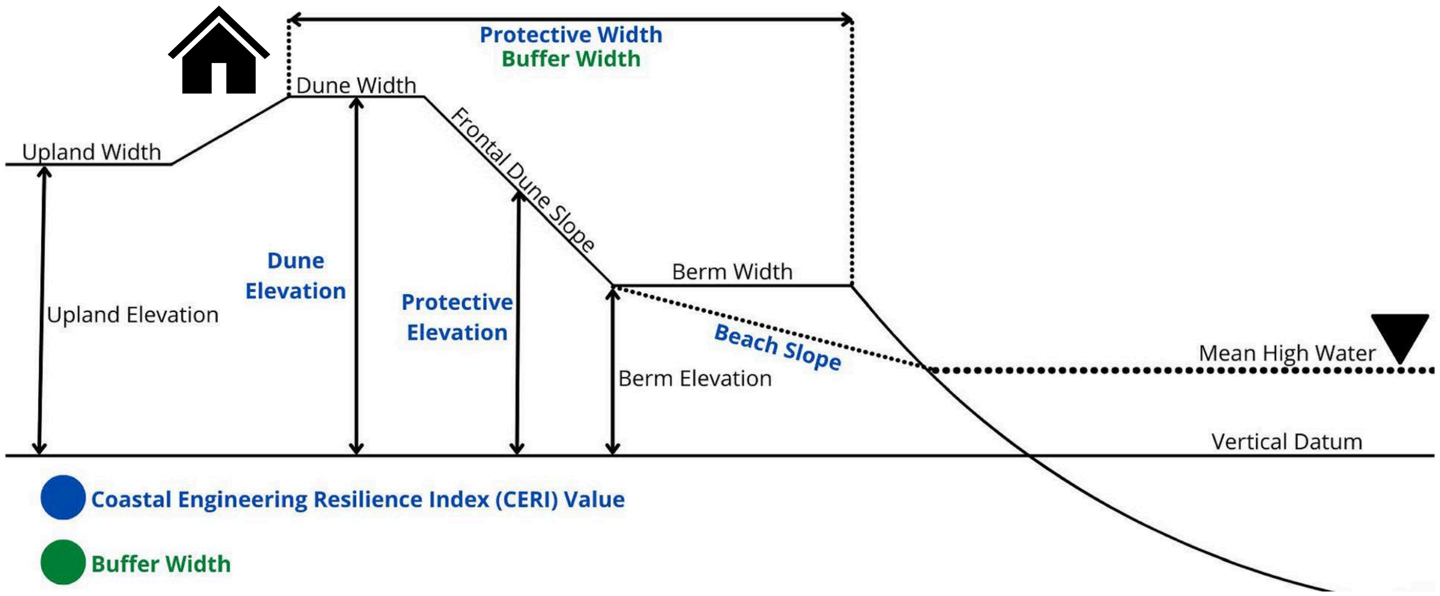
# The Coastal Engineering Resilience Index (CERI) is a metric incorporating LiDAR-derived geomorphic features to estimate a system's resilience.

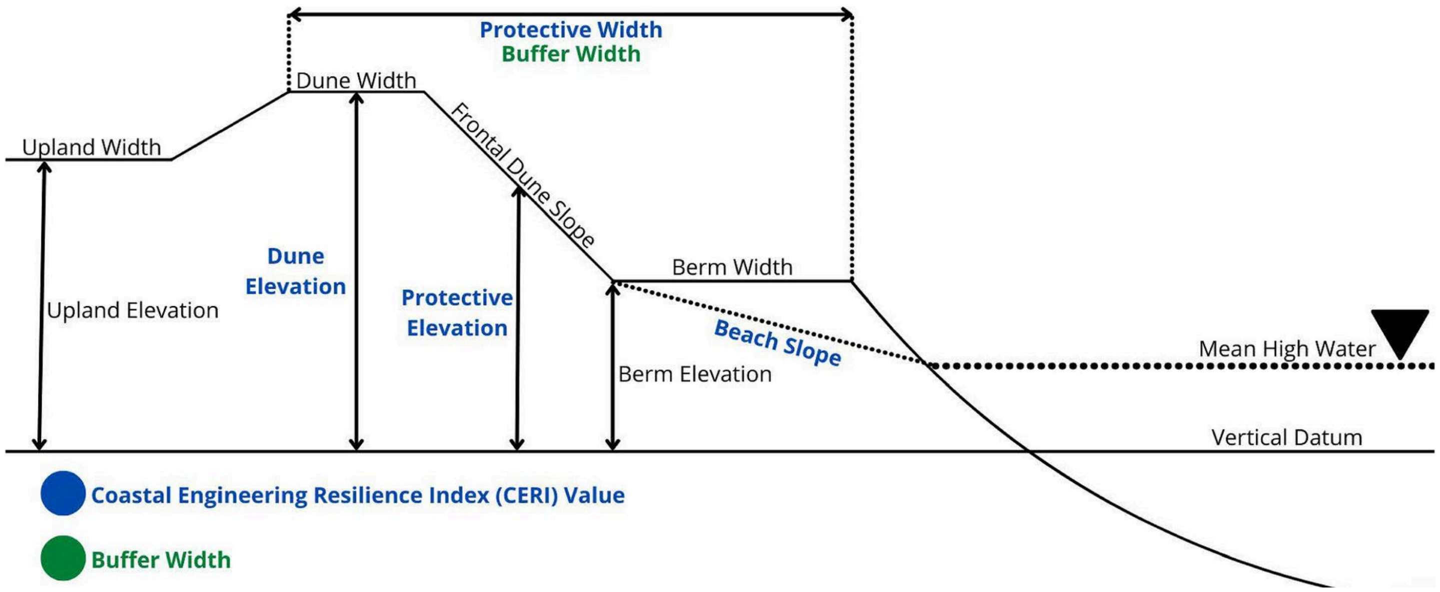



Spurgeon et al., 2023

CERI is a workflow run through the JALBTCX toolbox that:

- Extracts dune and beach features from lidar.
- Determines feature elevations and volumes.
- Incorporates local wave characteristics into runup and erosion models.
- Calculates a CERI index to estimate vulnerability.

# While CERI is commonly applied by USACE, it is generally applied to a single LiDAR dataset for a given study site.




Spurgeon et al., 2023

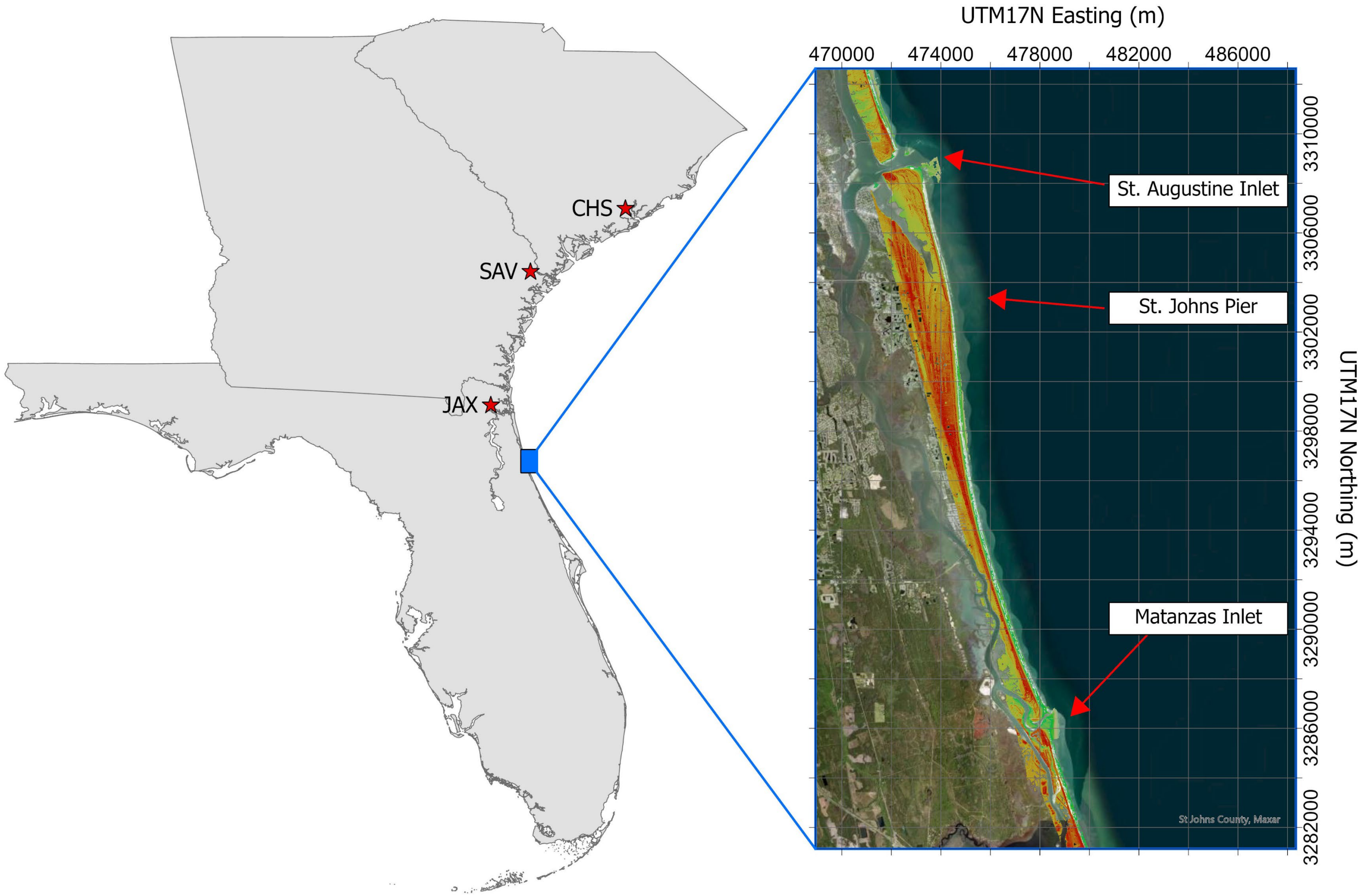
Application of CERI to a single dataset limits understandings of temporal variability.

- Resilience
- Morphologic features

While CERI incorporates the potential for wave induced erosion, it does not consider recovery potential.

- Aeolian recovery of dunes and beaches.

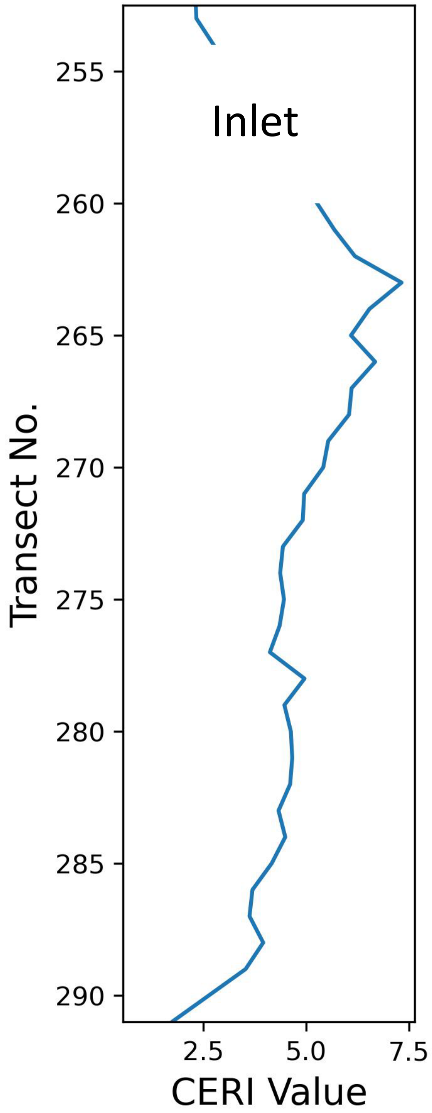
# Applying CERI in NE Florida allows us to investigate temporal variability of CERI for an area with different alongshore morphologies and influences.

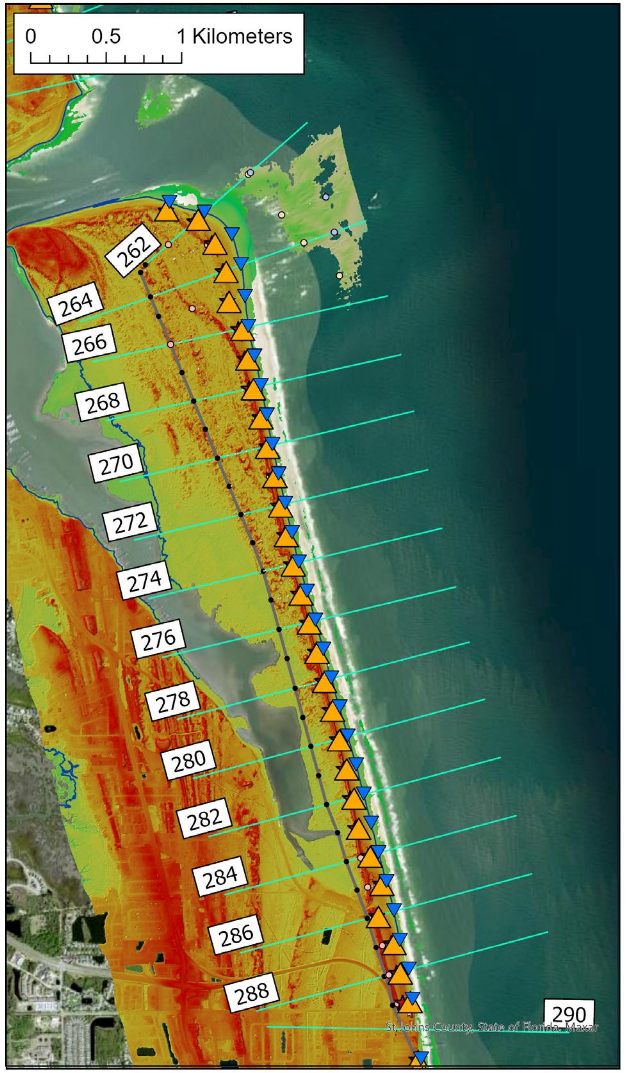


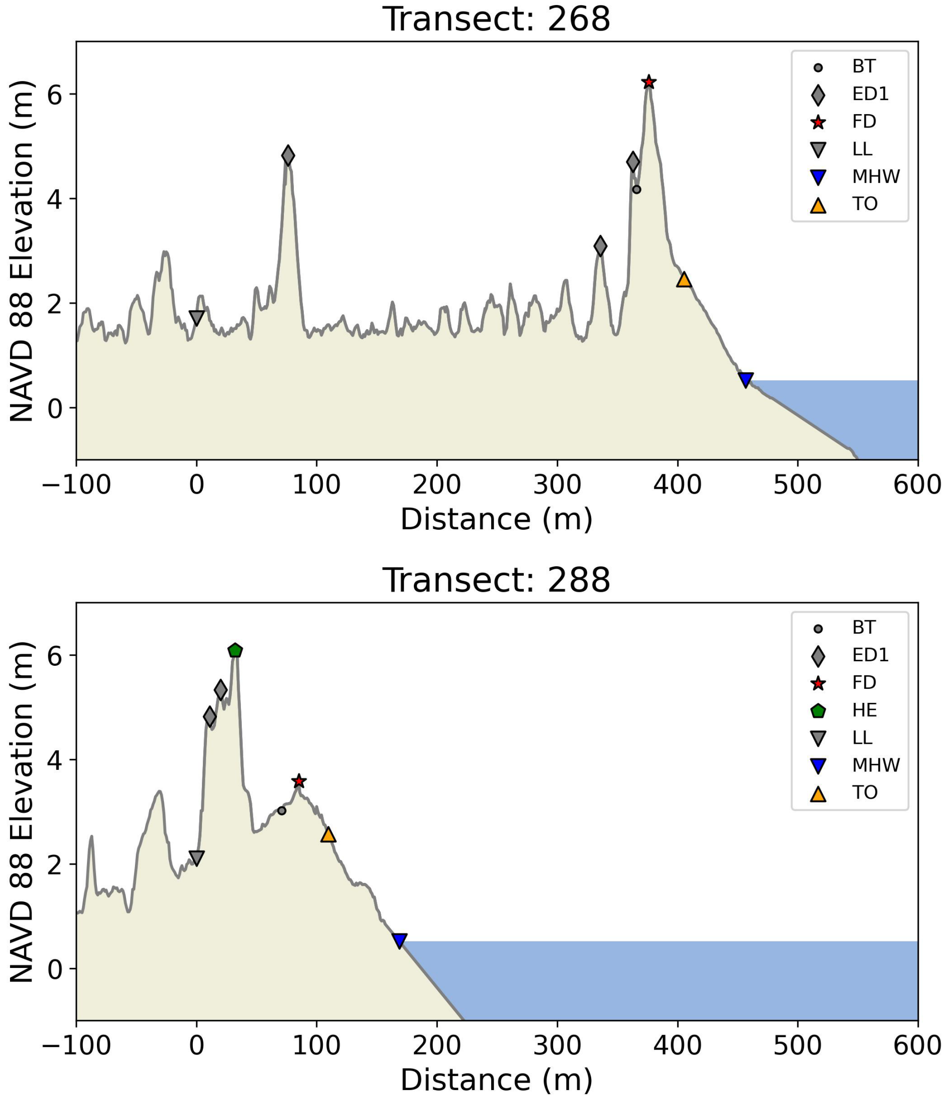

Numerous LiDAR datasets in the area allow us to investigate:

- Alongshore variance of CERI over ~10 years
- Alongshore variance of morphologic features
- The influence of changing morphologic features on recovery potential.

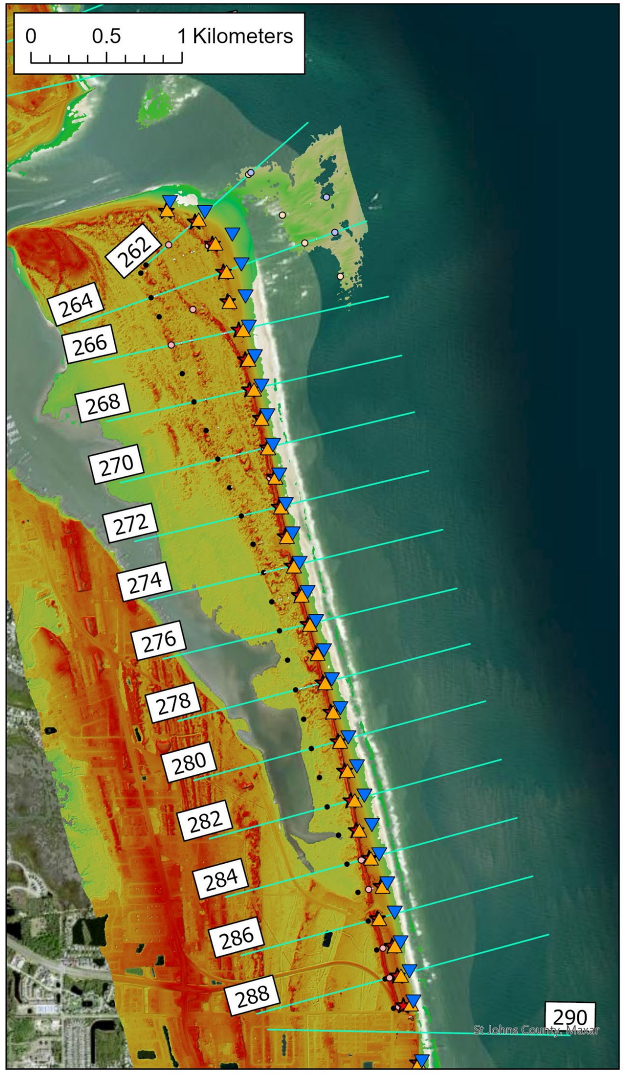
# Increased beach width and dune elevations result in greater coastal resilience and CERI values.



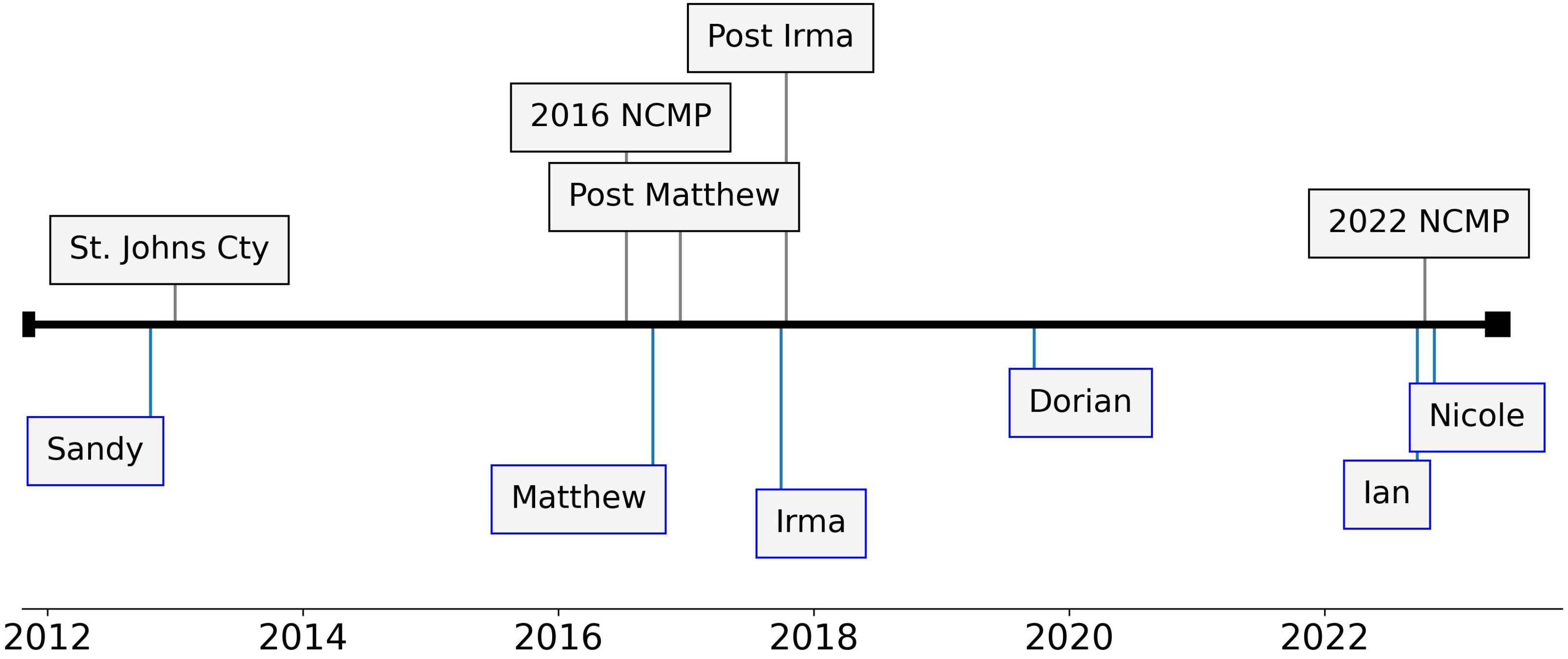



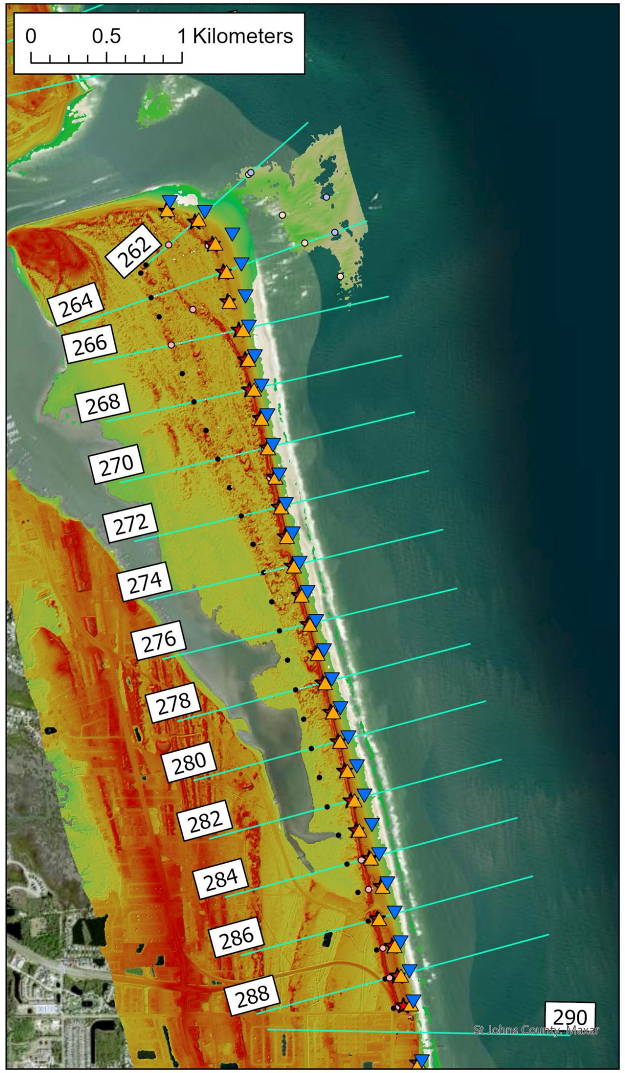
# NCMP and other LiDAR collections have been conducted several times in NE Florida.



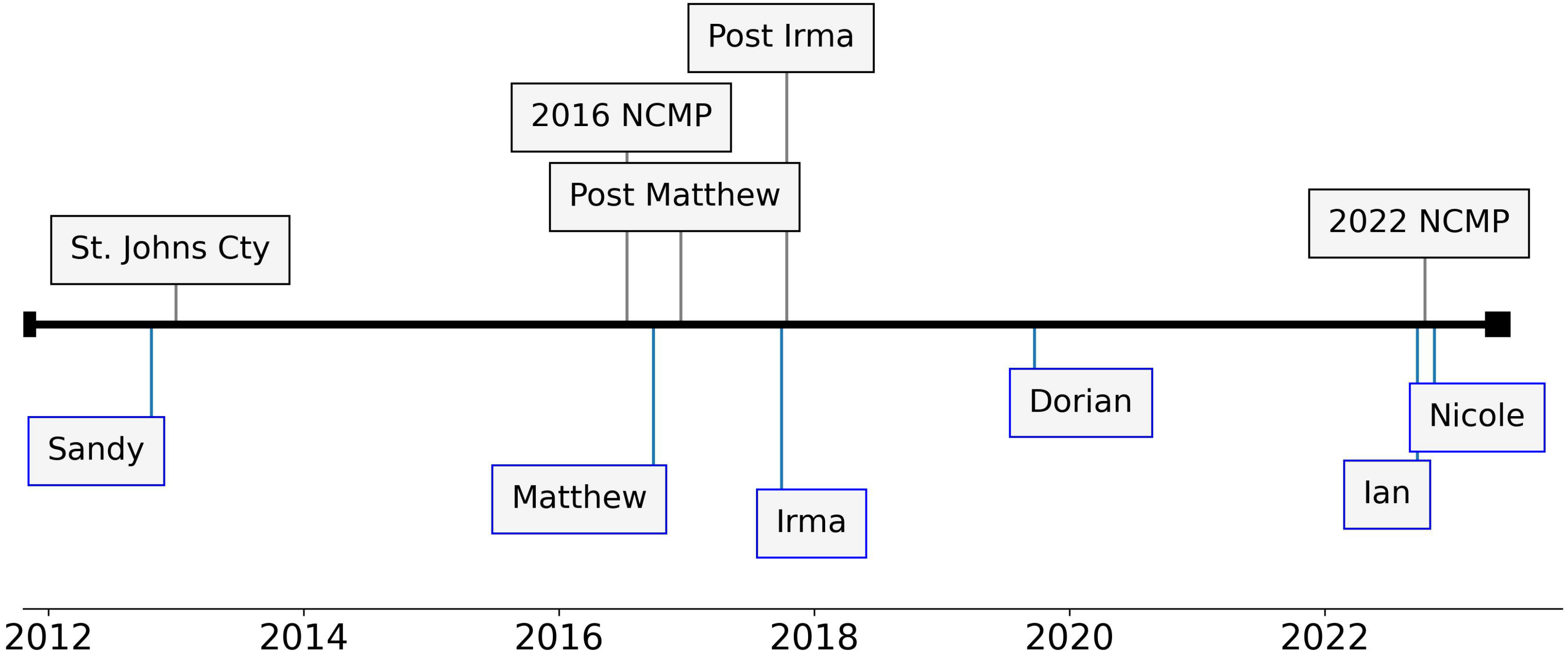

- Five LiDAR-derived DEMs are available over ~10 years in NE Florida
- Available data are typically post-storm surveys.



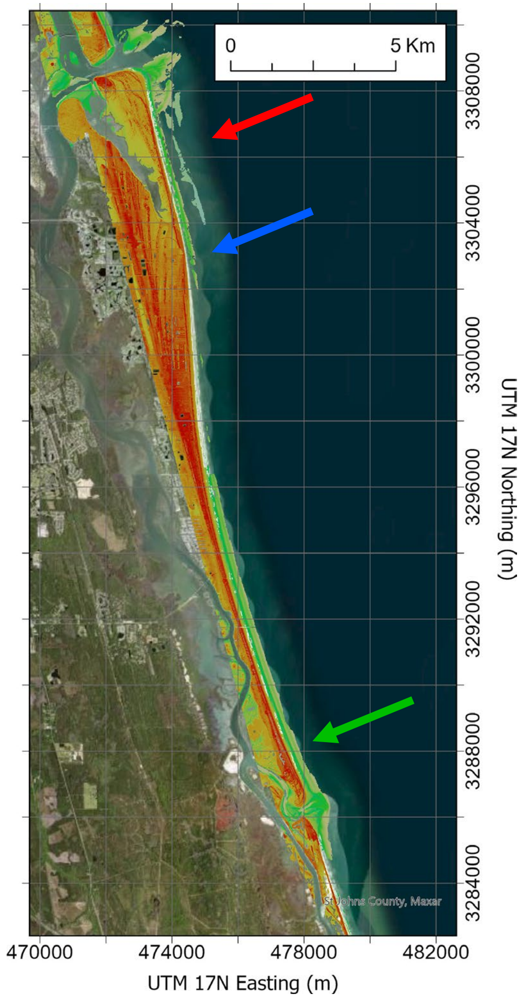
# The presence of numerous LiDAR datasets allows for the investigation of which regions of coastline are most dynamic.

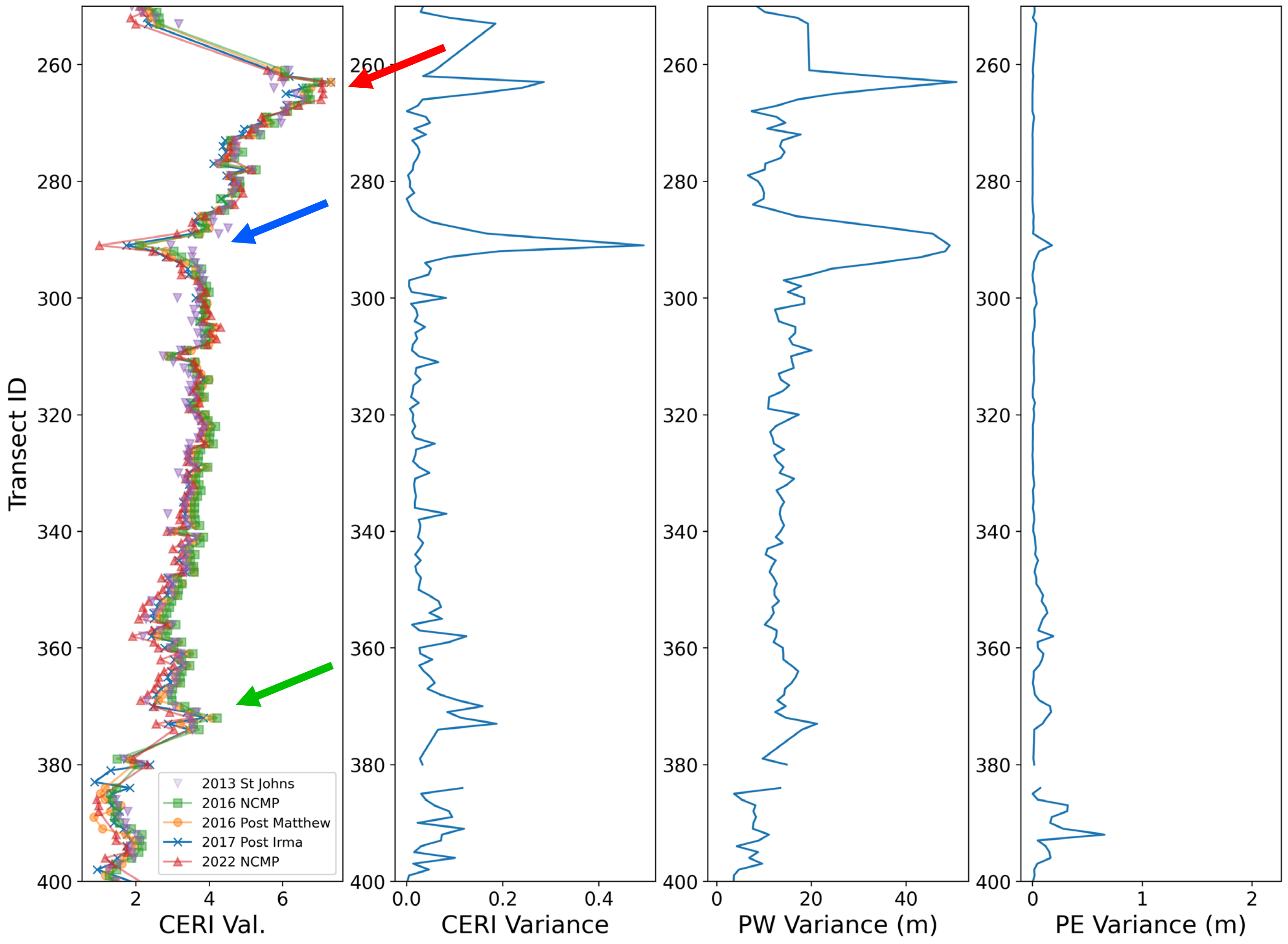



- CERI can be applied for each of these datasets.
- This allows us to determine which areas are most dynamic and most vulnerable.



# CERI values appear most variable in regions of beach nourishment and inlet-adjacent shorelines.

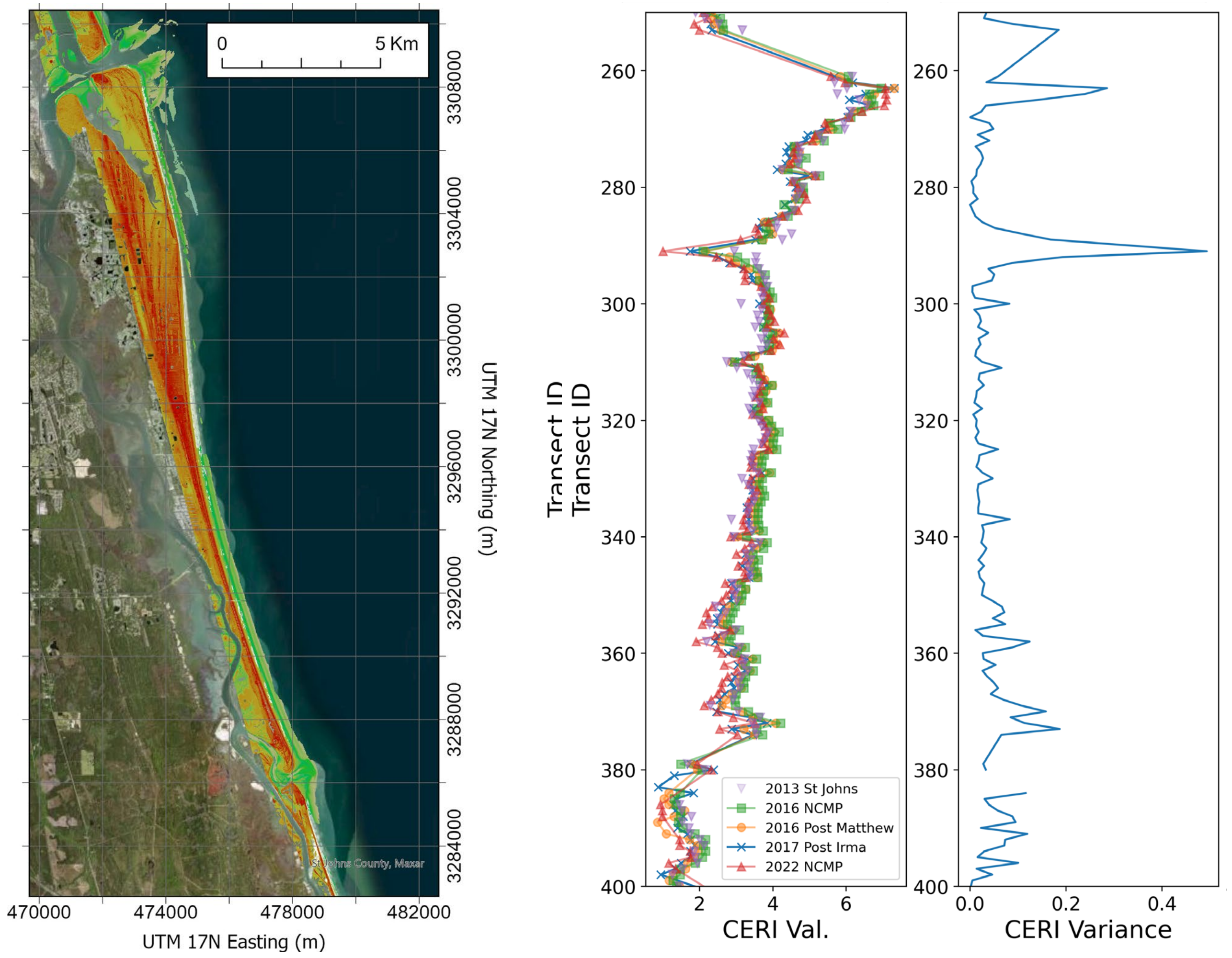





PW = Protective Width, PE = Protective Elevation

# While CERI variance highlights which areas are most dynamic, it does not indicate how beaches may change due to aeolian processes.




CERI variance can highlight potentially vulnerable areas.

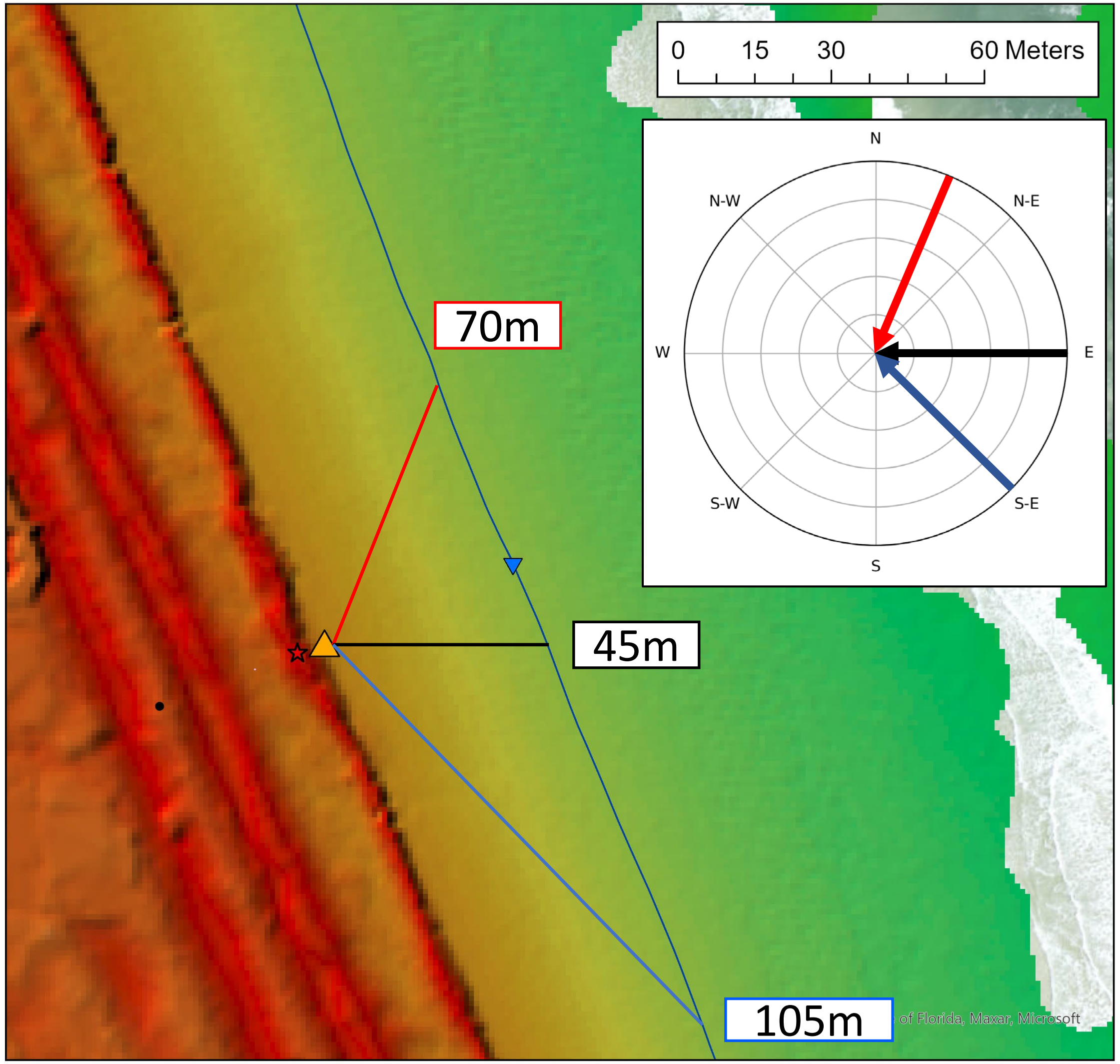
- High variance is indicative of <u>past changes</u> to beach width and height.
- This approach does not allow us to understand changes that <u>may occur</u> in the future.
    - Recovery potential

# Incorporating aeolian recovery potential may allow us to gain insight into how beach resilience may change.


Crescent Beach (Anastasia Island), FL has undergone natural dune recovery following the 2022 storm season.

- Significant aeolian dune toe recovery is apparent alongshore.
- Revegetation appears in some areas of recent sediment accumulation.
- Quantifying alongshore potential for dune recovery may improve coastal resilience of some areas and associated metrics.

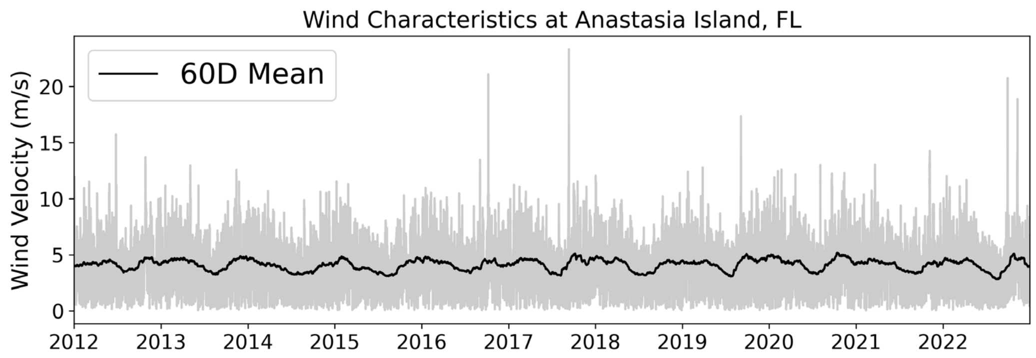
# To investigate aeolian recovery, CERI-derived morphologic features are coupled with wind fields to estimate recovery potential.

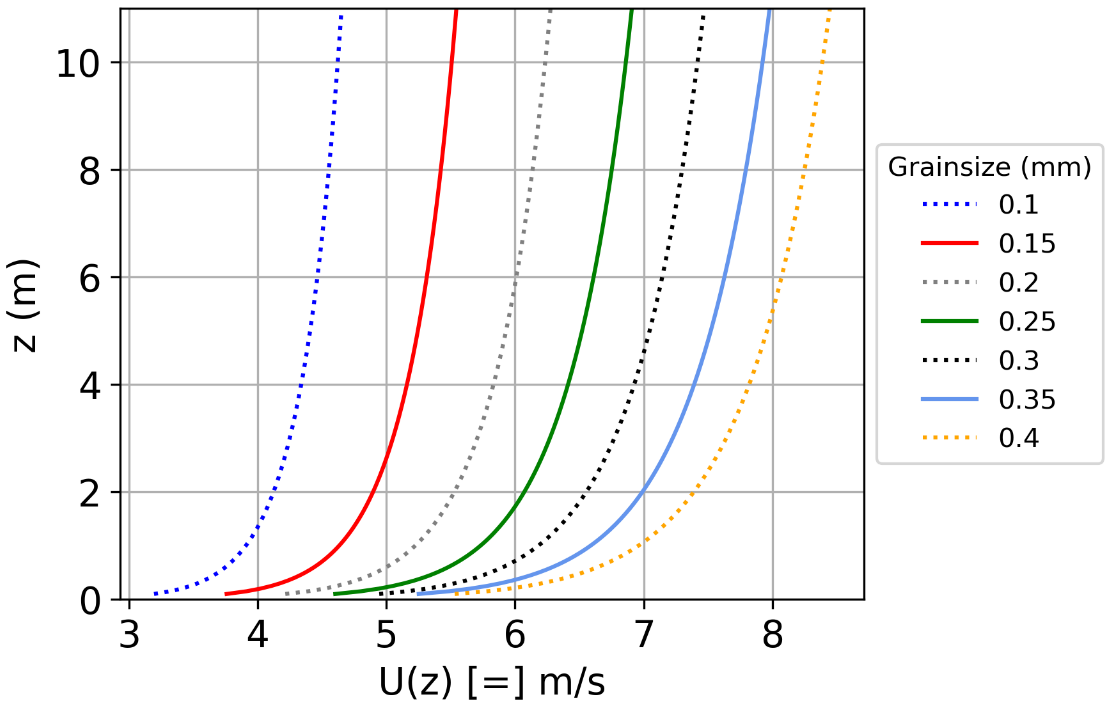



CERI-derived dune toes and mean high water lines are used to estimate the length of beach a wind vector crosses.

- Referred to in this work as “cross-shore fetch”.
- For a given beach configuration, oblique winds have greater cross-shore fetch.
  - Representative of sediment transport potential.
- A given wind direction can have a distinct impact on different beach geometries.

# ERA5 wind hindcasts over a ~10-year period can be coupled with this approach to estimate aeolian exposure of a beach.

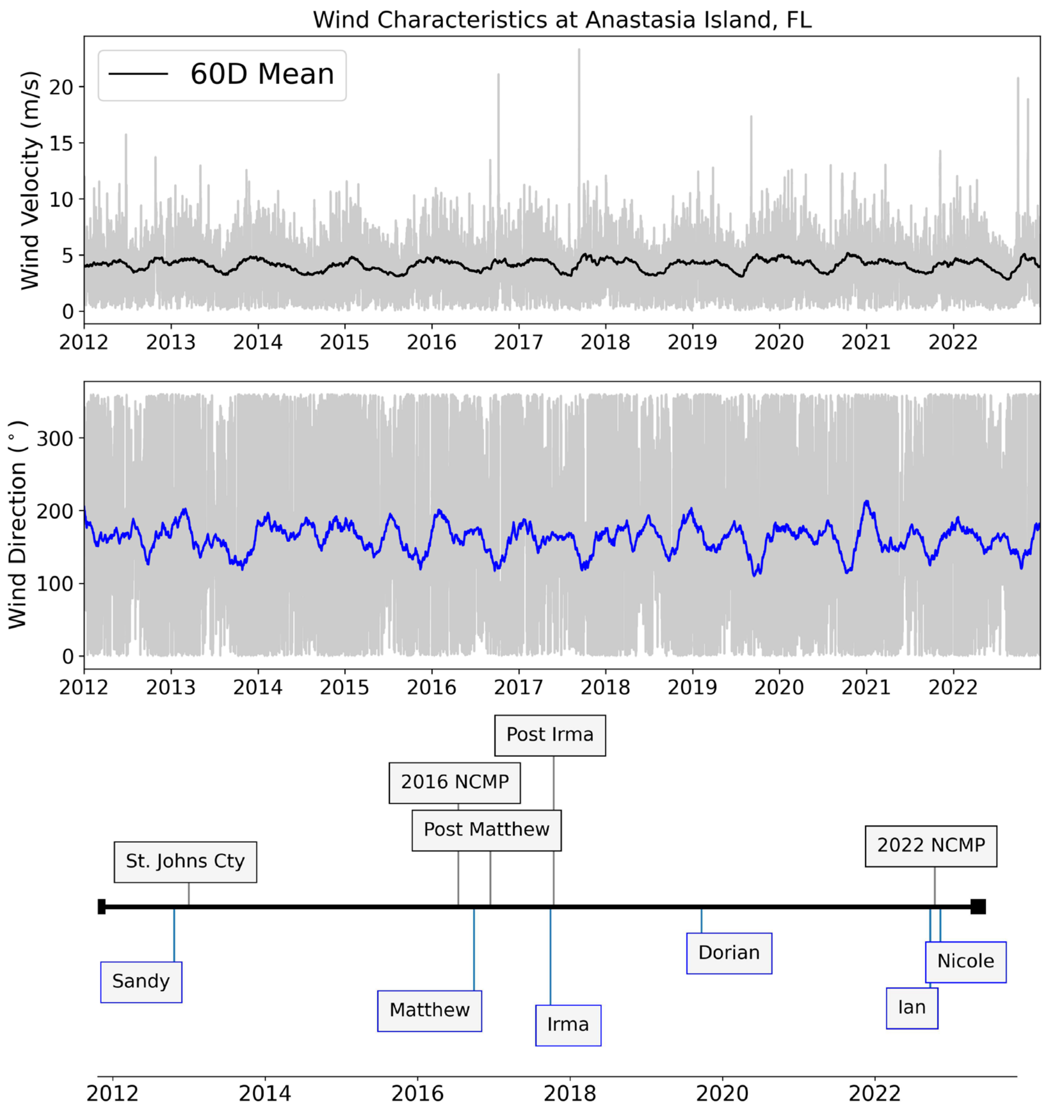



ERA5 wind hindcasts can be used to apply this cross-shore fetch approach over ~10 years.

- Prior to estimating cross-shore fetch, winds that cannot generate saltation are removed.
- Local sediment characteristics are used to calculate a threshold shear velocity.
- Threshold shear velocity translated to 10 meters.
  - Elevation of ERA5 wind hindcasts

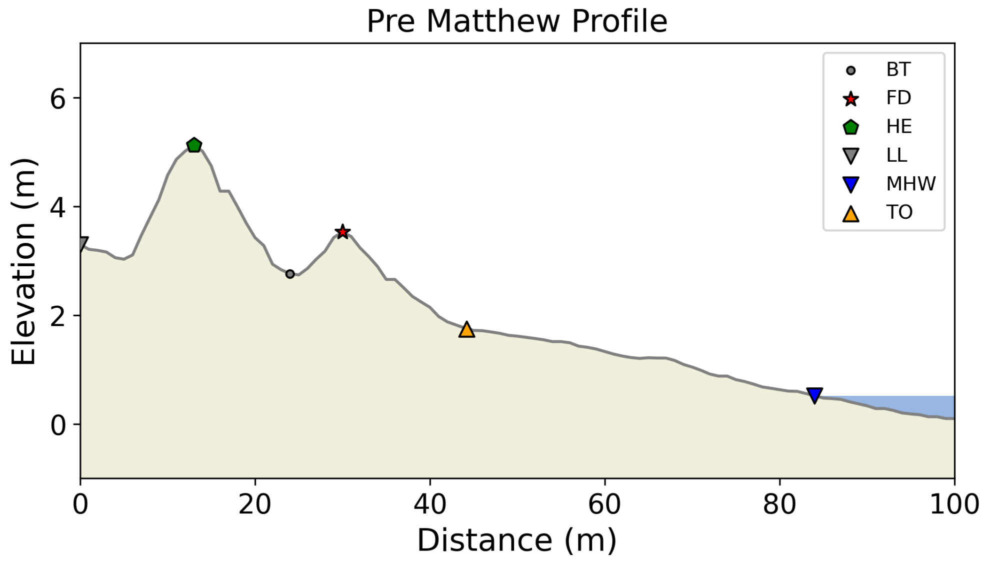
# ERA5 wind hindcasts over a ~10-year period can be coupled with this approach to estimate aeolian exposure of a beach.

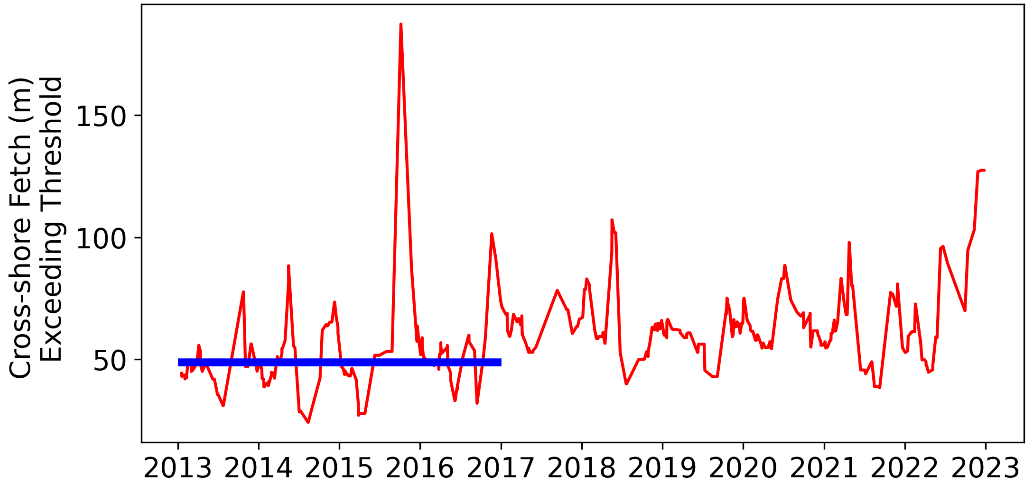



ERA5 wind hindcasts can be used to apply this cross-shore fetch approach over ~10 years.

- Multiple LiDAR datasets are available within this period.
- Morphologic features from these datasets can be used to estimate cross-shore fetch.
- This approach allows us to estimate cross-shore fetch over a 10-year period.
    - Updating morphologic features
    - Filtered wind data

# Preliminary results indicate dune retreat is conducive to increased aeolian recovery potential.




Prior to Hurricane Matthew, a prominent frontal dune existed.

- Beach width (TO→ MHW) was ~40 m
- Average cross-shore fetch of ~49 m

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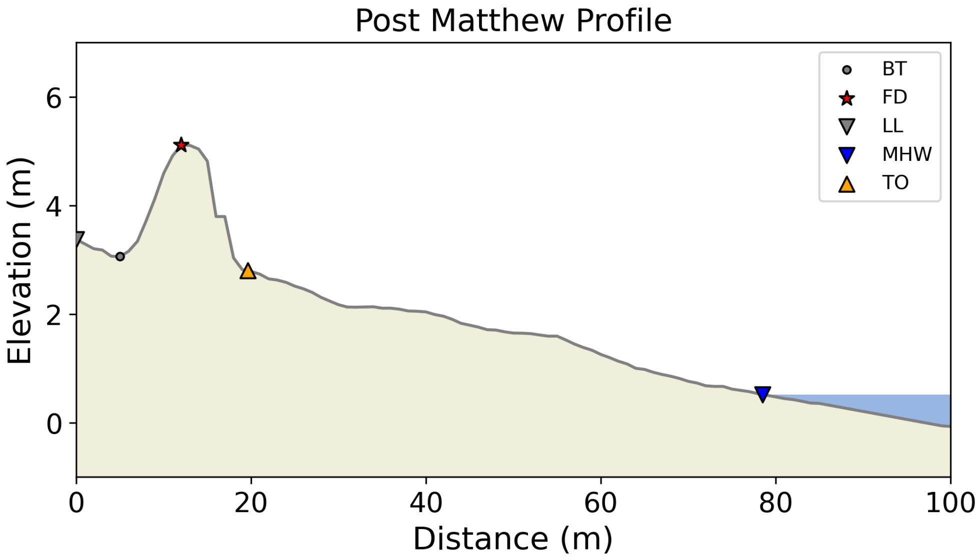
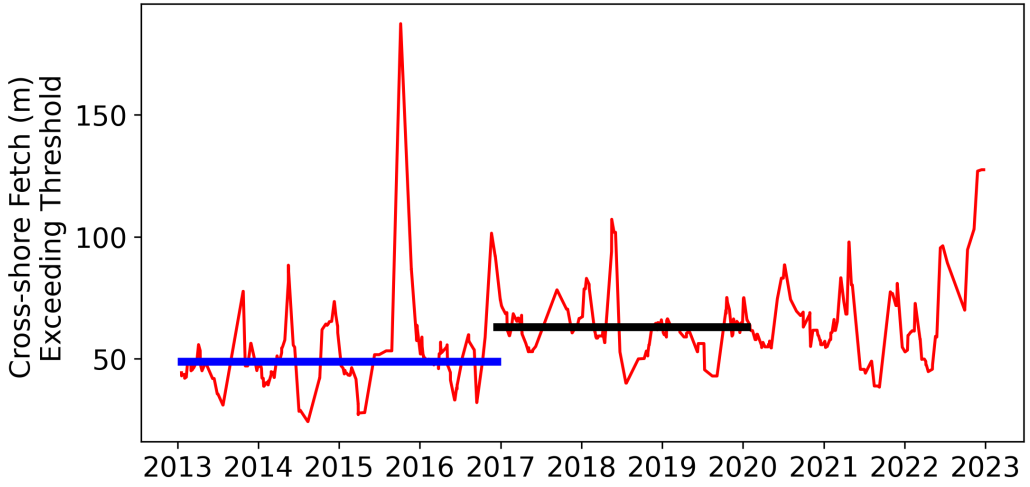


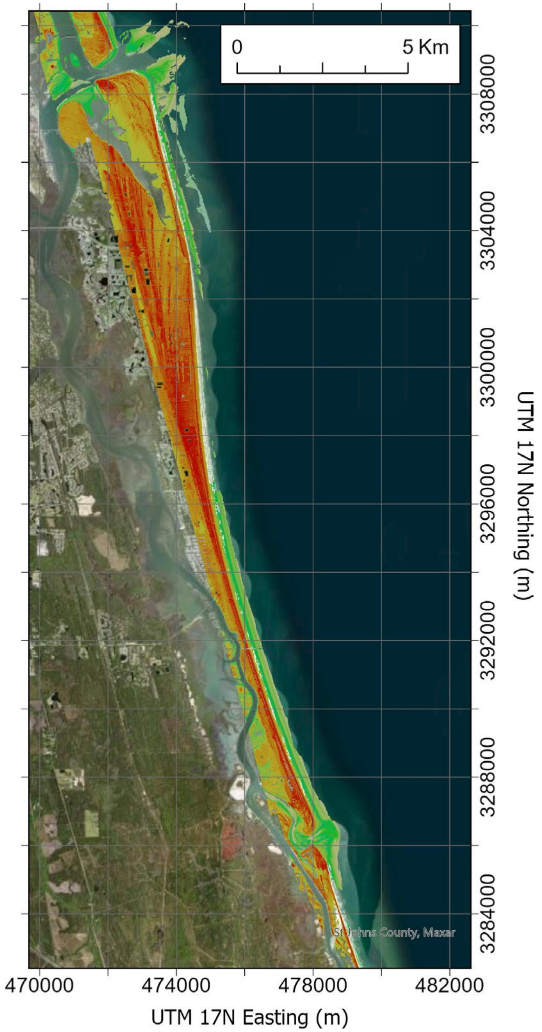

Prior to Hurricane Matthew, a prominent frontal dune existed.

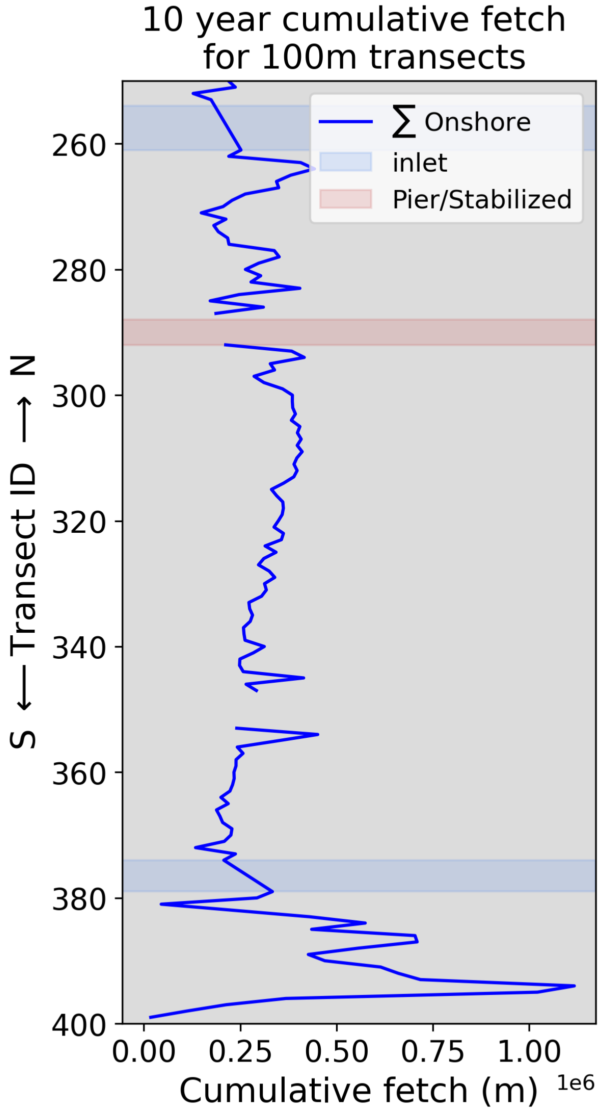
- Beach width (TO→ MHW) was 40 m
- Average cross-shore fetch of 49 m

Hurricane Matthew resulted in ~25 m of dune retreat at S Anastasia Island.

- MHW level moved inland only 5.5 m increasing beach width to 59 m.
- Average cross-shore fetch increased to 63 m.
- Retreating dunes increase cross-shore fetch following Matthew.

# This same approach can be applied at the mesoscale as a proxy for potential aeolian recovery.

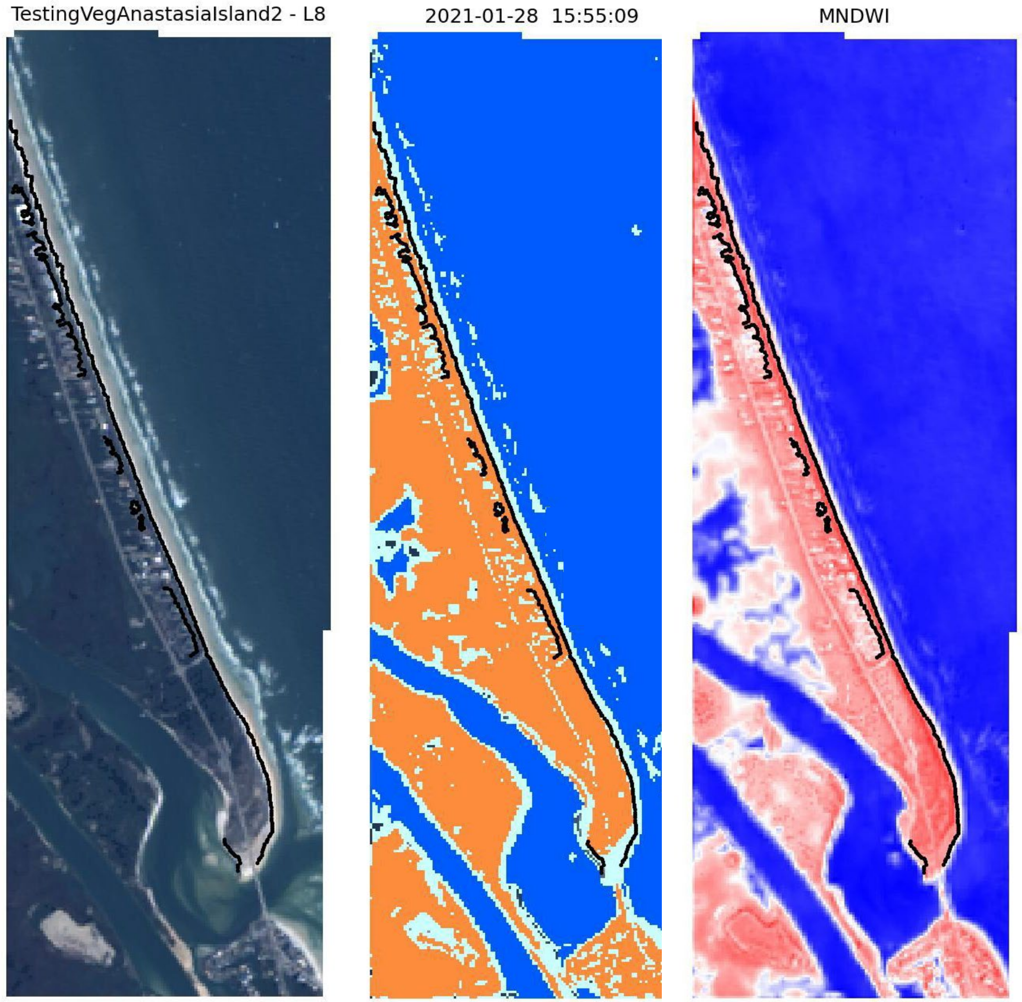



Cumulative cross-shore fetch can be estimated for 10's of kilometers of shoreline over decadal time periods.

- Generally, increased cross-shore fetch corresponds to areas with greater beach width.
- More work needs to be conducted to see where cross-shore fetch has changed.
- More work is needed to convert cross-shore fetch and wind characteristics to transport potential.

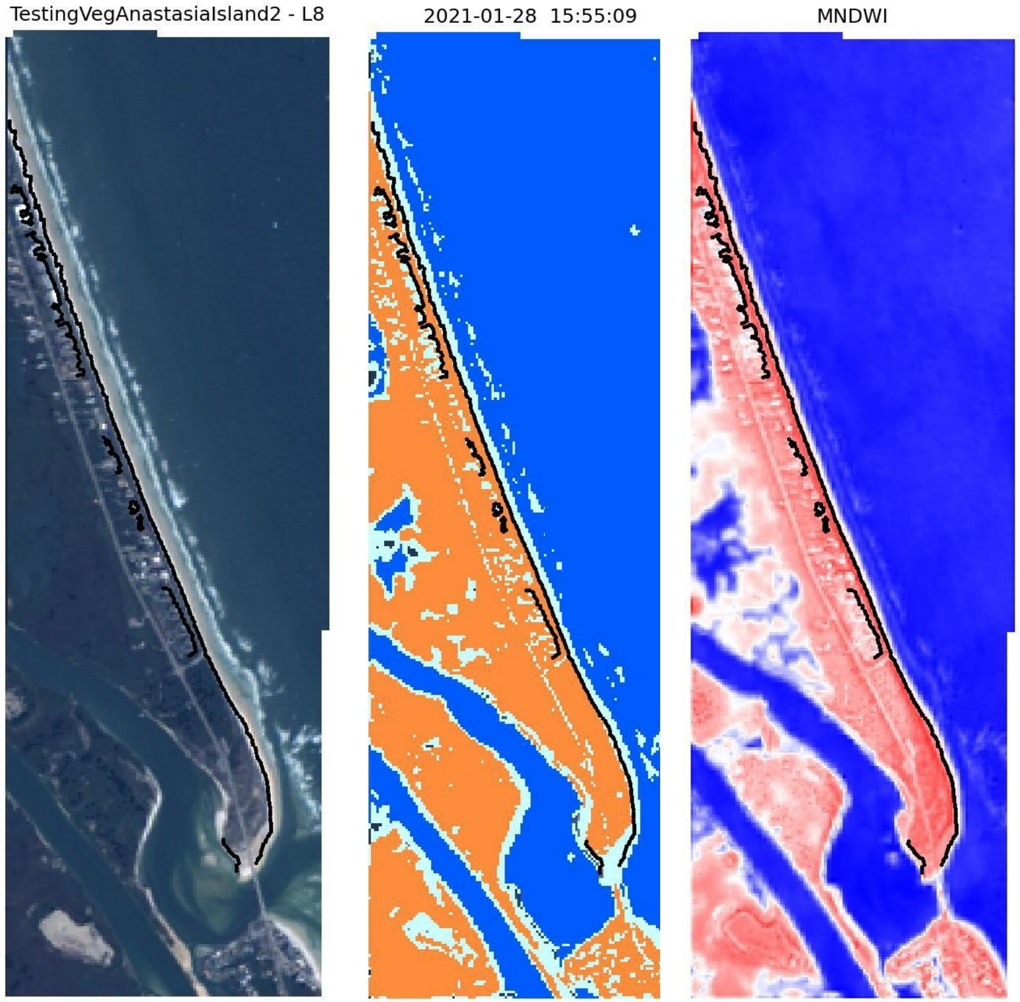
# Future work – Comparing our results to satellite imagery can allow us to determine morphodynamic feedbacks from these aeolian processes.




Retraining of CoastSat can allow us to:

- Identify vegetated and non-vegetated regions as a proxy for dune location.
- Develop a >10-year time series of cross-shore dune position and estimate advance and retreat.
    - Greater temporal resolution than LiDAR collections.
- Correlate advance and retreat rates to cross-shore fetch estimates from LiDAR data.

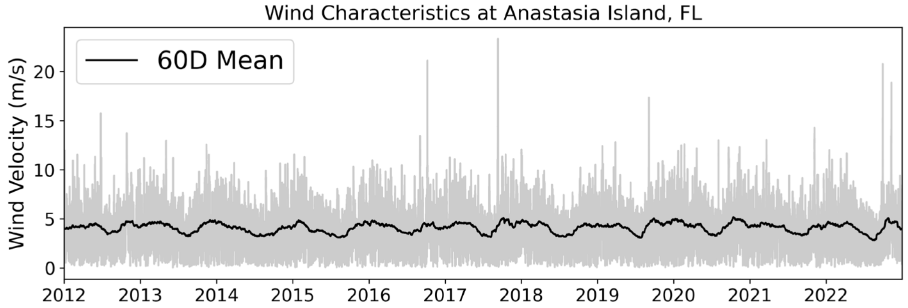
# Summary and key points



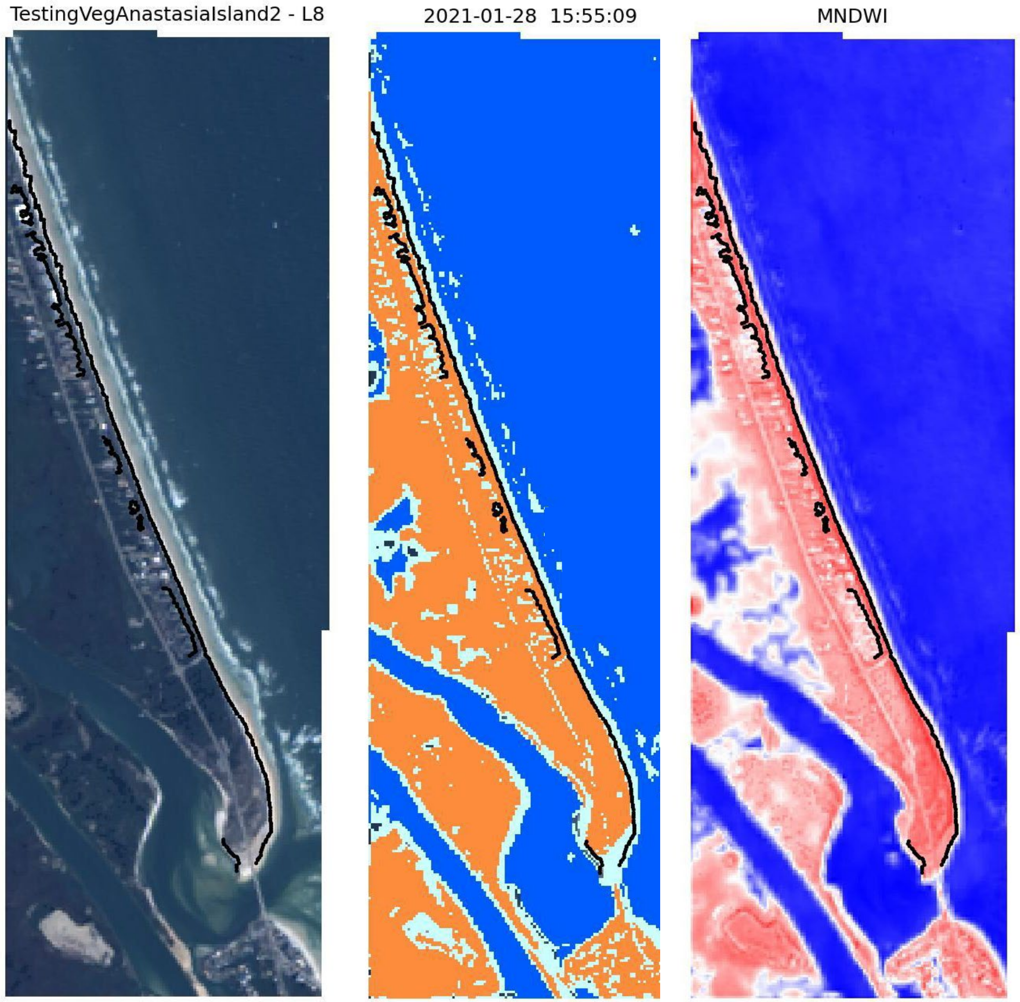

- Application of CERI over numerous LiDAR datasets allows us to determine variability in coastal resilience and morphologies.

- CERI feature extractions coupled with wind hindcasts may be able to reveal areas with the potential for aeolian dune recovery.

- More work is needed to translate cross-shore fetch into aeolian flux of sediment contributing to dune recovery.



# Questions?



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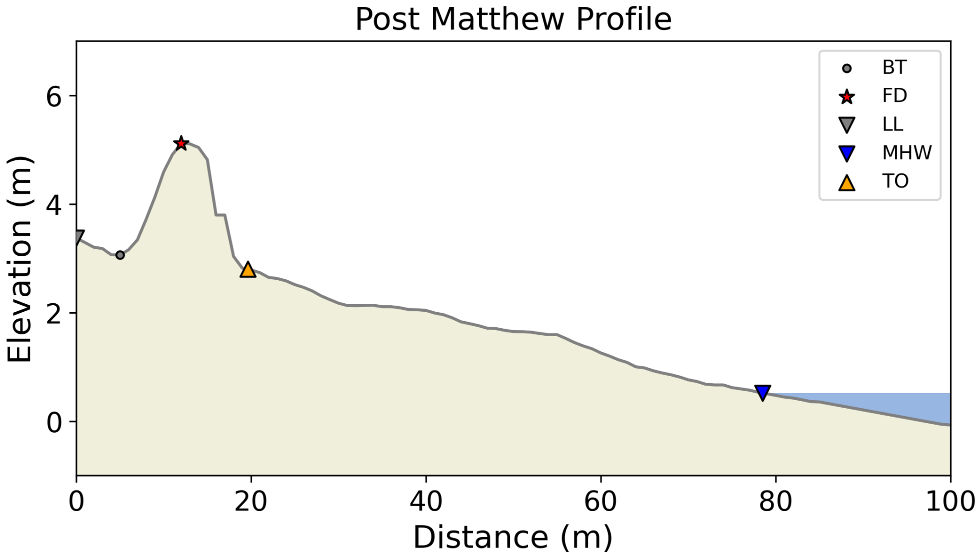
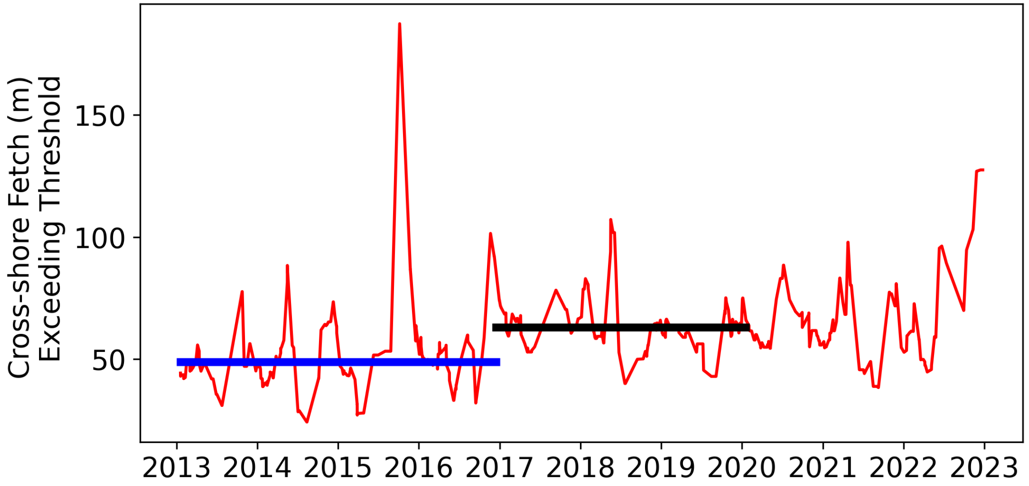


Post Matthew Profile
Elevation (m)
Distance (m)
BT
FD
LL
MHW
TO
0
2
4
6
0
20
40
60
80
100

Cross-shore Fetch (m)
Exceeding Threshold
50
100
150
2013 2014 2015 2016 2017 2018 2019 2020 2021 2022 2023